

Agenda

Activity

- Introduction (8739.7 vs S20.20-1999)
- ESD principles, methods, and requirements
- Handling principles, methods and requirements

FYI

NASA-STD-8739.7
December 1997

Electrostatic Discharge Control

(Excluding Electrically Initiated Explosive Devices)

∠ Canceled February 27,2002

Z Valid for existing contracts

ANSI/ ESD S20.20-1999 May 16,1999

Protection of Electrical and Electronic Parts, Assemblies and Equipment

(Excluding Electrically Initiated Explosive Devices)

∠ Future acquisitions should cite ANSI/ESD S20.20-1999

NASA-STD-8739.7

For existing contracts



Card and Certificate



ID#	NASA Goddard Space Flight Center Greenbelt, MD 20771		
123	Greenbelt, MD 20771		
NASA ASSURANC	E STANDARDS PROGRAM		
NAME: ARI	ARLENE RABINOWITZ		
Organization:	HEI		
has completed training for:	PROGRAM MONITOR		
To: NASA-STD-8739.7, ES	ED CONTROL		
Expiration Date:	APRIL 20, 2000		

Retraining every 2 years



<u>Page 6-1, Para 6.1-2,</u>: The supplier is responsible for <u>certifying</u> and maintaining the certification of each individual who is involved in ESD control.

<u>Page i:</u> Note: The term supplier shall be defined as In-House NASA, NASA contractor and subtier contractors

NASA -STD-8739.7: Chapter 1 - Scope

Page 1-1, Para 1.1-2: Purpose

Special requirements may exist that will not be covered by or will not be in conformance with requirements of this publication. Engineering documentation shall contain the detail for these requirements, and shall take precedence over conflicting portions of this publication when they have been approved in writing by the procuring NASA Installation.

<u>Page 1-1,Para 1.2 :</u> <u>Applicability</u>

This publication is applicable to all NASA programs involving ESD Sensitive (ESDS) components or assemblies, and wherever invoked contractually. These measures shall be implemented during all phases of receiving, inspection, assembly, testing, repair, storage, and packaging for shipping of all items designated as ESDS.

Why ESD Training?





- To understand the fundamentals of static electricity.
- To control and prevent ESD in areas with ESD Sensitive (ESDS) parts/assemblies.
- To become familiar with methods for protecting ESDS parts / assemblies.
- □ To become familiar with NASA –STD- 8739.7 "
 □ Electrostatic Discharge Control"

Today's Technology





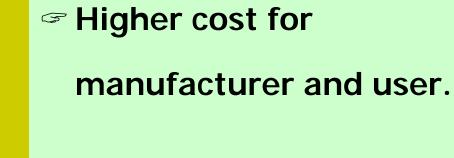




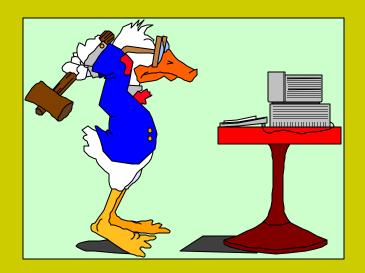


Impact of Ignoring ESD



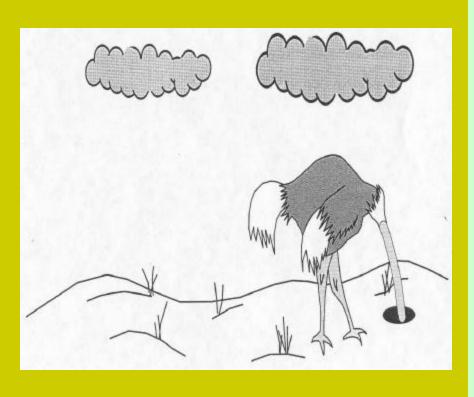


Lower product quality.

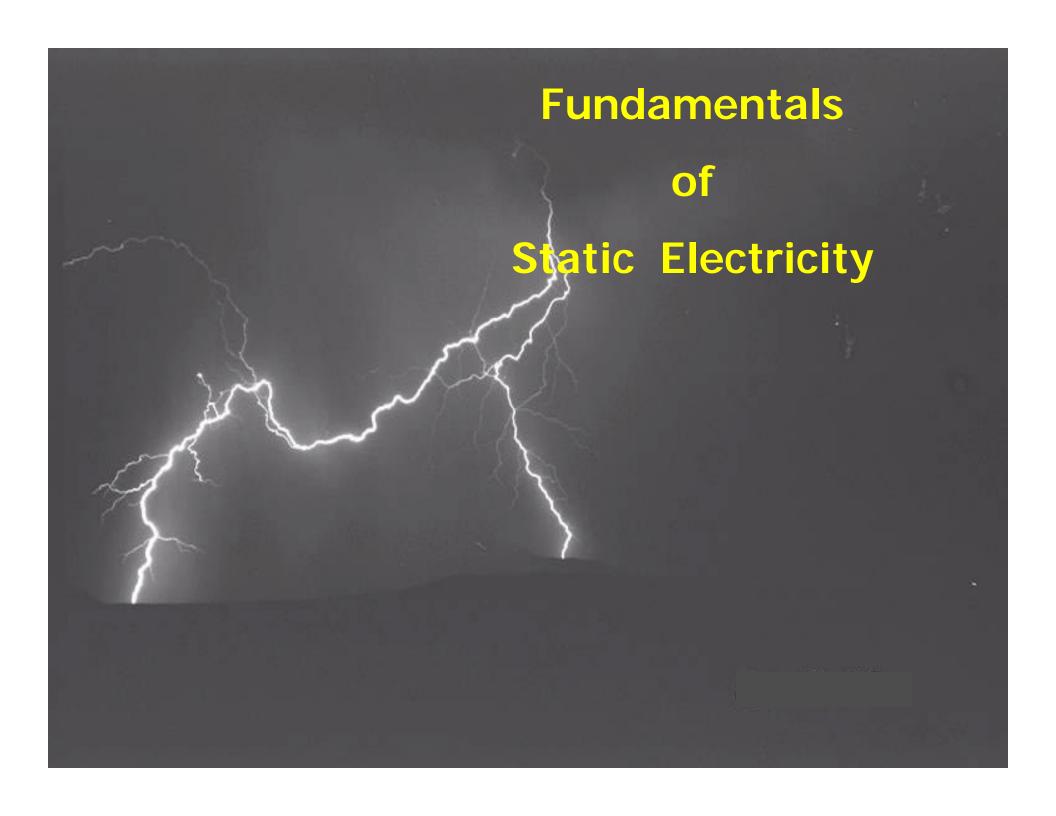


Unhappy customers, especially if part or assembly fails at a critical time.

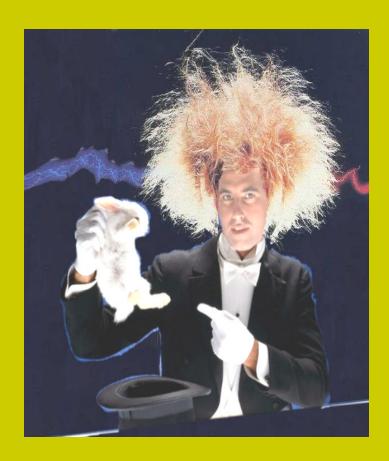
Reasons for Disbelief in ESD Damage



- **∠** Damage often invisible under ordinary optical microscope.
- Assorted parts affected; no trend.



Static Electricity



ESD: A hare raising experience

STATIC:

Having no motion; at rest

STATIC ELECTRICITY:

Electrical charge at rest.

∠ FYI

- Electrical charges are caused by an imbalance of electrons on the surface atoms of materials.
- Primarily due to triboelectric
 charging between materials where electrons from surface atoms are transferred between materials creating an electrostatic potential.
- Electrostatic field surrounds electrostatically charged objects.

Electrostatic Discharge (ESD)



A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

Static Charging Methods

- Triboelectric method
- Pertaining to electricity generated by friction.
- Static charge generation by contact and separation of materials.
- Prime method in the electronics industry.
- Emphasized in this class.

Inductive method

- Electric fields surround electrostatically charged objects.
- Electric fields influence the properties of materials placed in the field.
- No physical contact between objects.

TRIBOELECTRIC CHARGING METHOD



(Tribo - "to rub")

Page 3-2, Para 3.1

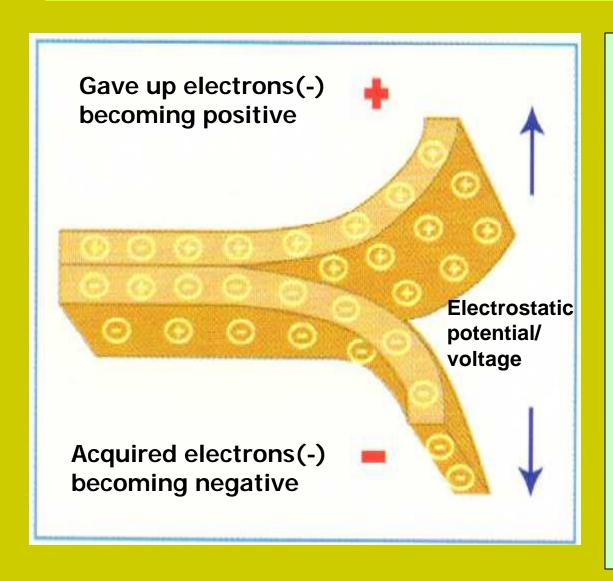
Triboelectric:

Pertaining to electricity generated by friction.

Factors Affecting Triboelectric Charge Generation

- Intimacy of contact
- Speed of separation
- Conductivity / resistivity of materials
- ≪ Relative position in the <u>triboelectric</u> series

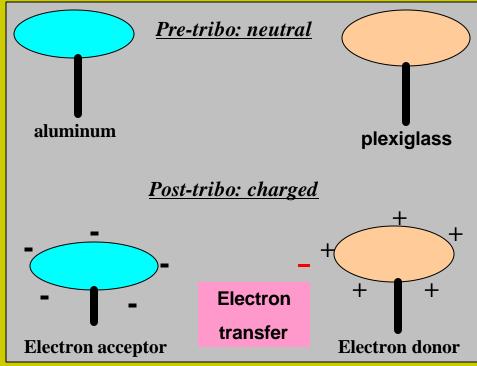
Example 1: Material Separation



- Intimate contact and material separation results in electrical charge.
- Speed of separation/ rubbing determines the strength of the electrostatic field.
- Electrostatic potential (voltage).

Example2: Aluminum vs Plexiglass

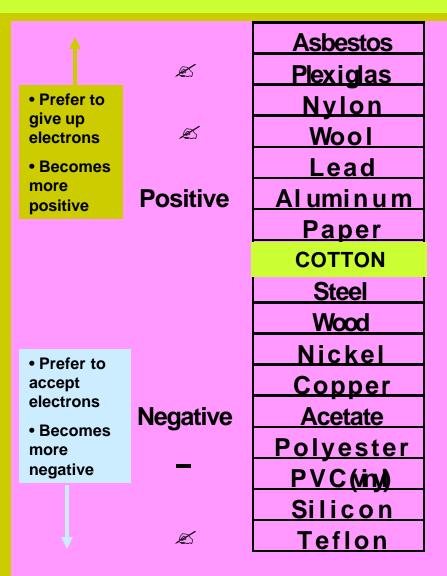




- ✓ During the rubbing process, electrons (negative charge) are transferred from the plexiglass (donor) to the aluminum (acceptor). The plexiglass now has a positive charge and the aluminum is negative.
- ★ The aluminum and the plexiglass are now electrostatically charged which means <u>electrostatic potential</u> exists between them. The electric field strength depends on the speed of rubbing.

Sample Triboelectric Series

(A ranking of materials by the order in which they *lose* or *gain* electrons)



- When two materials contact and separate, the material nearer the top of the series takes on a positive charge, the other a negative charge.
- ✓ Materials further apart typically generate a higher charge than those that are closer together.

 ✓/>
- Materials close to one another can produce charge polarities opposite to that expected.

Note: The series should be considered a guide to polarity and relative charge magnitude. Common

ESD

Events

ESD event #1



ELightning

- Clouds become highly charged due to rapid vertical movement of air molecules and other particles (triboelectric charging).
- High voltage potential is created between clouds or between clouds and earth.

.... ZAP

ESD event #2



Door knob shock

- Triboelectric charging between person's footwear and floor.
- When the voltage potential between the electrostatically charged person and the door knob exceeds the air's insulative property, then

ZAP / PAIN / Z

Typical Electrostatic Voltages VS Relative Humidity

Means of Static Generation	<u>10 to 30 %</u> RH	<u>30 to 70%</u> RH	<u>70 to 90%</u> RH
Walking across a carpet	35,000 volts	7,500 volts	1,500 volts
Walking over vinyl floor	12,000 volts	3,000 volts	250 volts
Worker at bench	6,000 volts	400 volts	100 volts
Vinyl envelopes for work instructions	7,000 volts	1,500 volts	600 volts
Common poly bag picked up from bench	20,000 volts	6,500 volts	1,200 volts
	18,000 volts	5,000 volts	1,500 volts
			23

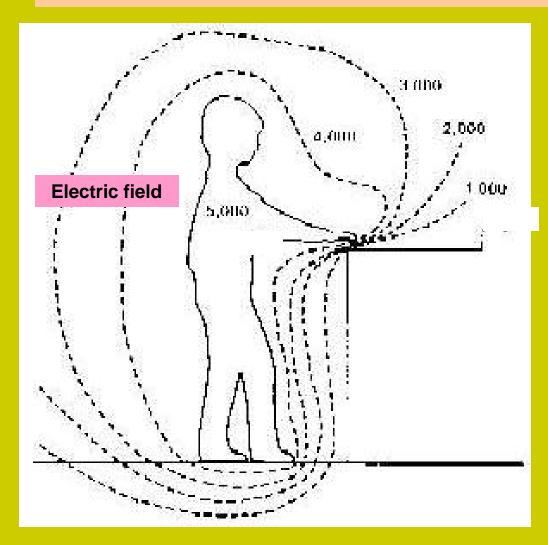
Inductive Charging

Electrostatic Field

NASA 8739.7, Page 3-1, Para 3.1

"A voltage gradient between an electrostatically charge surface and another surface of a different electrostatic potential"

Electrostatic Field (1 meter rule)



FYI: Electric field strength decreases with distance from electrostatically charged object.

- Electric fields surround electrostatically charged objects.
- ESDSensitive parts
 / assemblies:

 "A grounding
 device shall be
 worn by all
 personnel coming
 within 1 meter
 (3.3 feet) of any
 ESDS item."

 Page 7-4, Para
 7.2-5

Properties

of

Materials

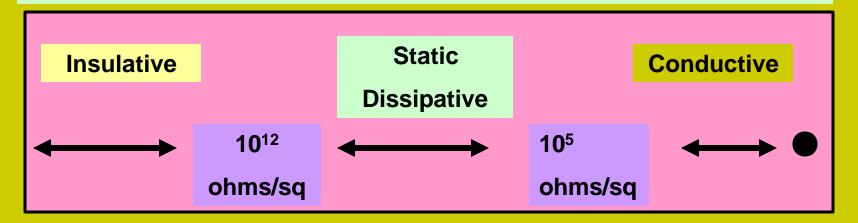
Material Properties

Materials possess characteristics such as:

- a. color, weight, smell
- b. density
- c. elasticity
- d. tensile strength
- e. electrical resistance
 - f. etc., etc., etc. ("King and I")

Surface Resistivity

NASA 8739.7 groups ESD materials as <u>insulative</u>, <u>static dissipative</u> and conductive.



<u>CONDUCTIVE material</u>: redistributes electrical charge rapidly preventing a buildup of charges. Rapid discharge can damage components/assemblies

<u>STATIC DISSIPATIVE material</u>: redistributes electrical charges at a slower rate.

<u>INSULATIVE material</u>: holds the charge and prevents redistribution of electrical charge.

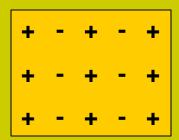
EXECUTE Page 7-1, para 7.2-3: All work surfaces in an ESD-protected area shall be STATIC DISSIPATIVE and electrically connected to the COMMON point ground.

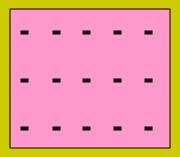
Insulators VS Conductors

Insulator

Conductor

A charged insulator can remain charged for many hours/days. Opposite polarity can exist on an insulator at the same time

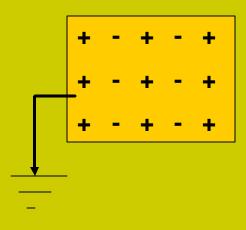




Charge of one polarity can remain on a conductor as long as it is isolated from ground.

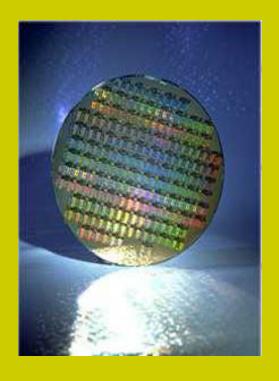
Charge will not migrate on insulators

Grounding insulators neither removes nor prevents surface charges

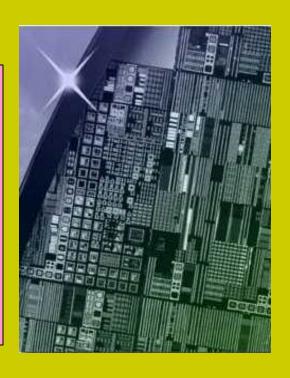


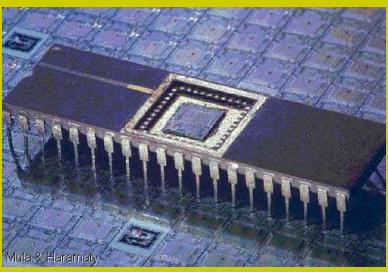
A charged conductor will discharge completely when grounded.

CAUTION: that styro-foam cup, plastic materials, or insulators on your work bench are static generating materials!!



Today's Technology

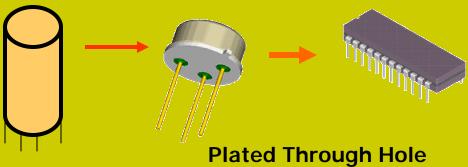




Advances in Part Design







(PTH)

Vacuum

Tube



Note closeness of parts, smaller parts, densely populated

Advances in the INTEL Microprocessor

(A reprint from the Wall Street Journal 8/26/96)

MICROPROCESSOR	SPEED (MIPS) Millions of instructions persecond	NO. OF TRANSISTORS	DATE INTRODUCED
4004	0.06	2,300	1971
8080	0.6	6,000	1974
8086	0.8	29,000	1978
80286	2.7	134,000	1982
386	6.0	275,000	1985
486	13.0	1,185,000	1991
PENTIUM	100.0	3.1 million	1993
PENTIUM PRO	440.0	5.5 million	1995
* PENTIUM II	(300 MHz)	7.5 million	1998
* PENTIUM III	(866 MHz)	28 million	1999
* PENTIUM 1V	(1.5 GHz)	42 million	2000

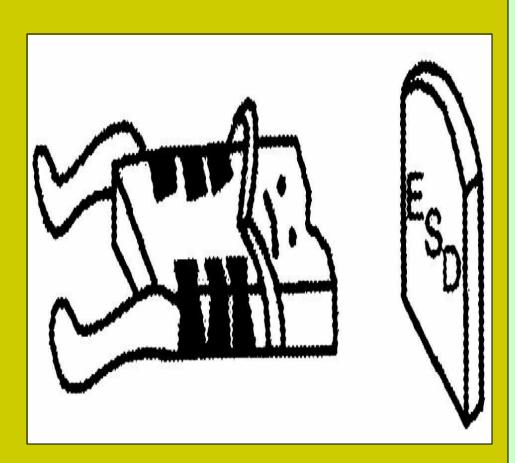
^{*} added

Types of ESD Failures

Catastrophic or Immediate Failure



Catastrophic or Immediate Failure



A failure that has rendered a device useless after exposure to an ESD event

Results in:

- Immediate failure
- Ease of detection
- Appears in failure reporting system

Latent or Degraded Failure

(walking wounded)



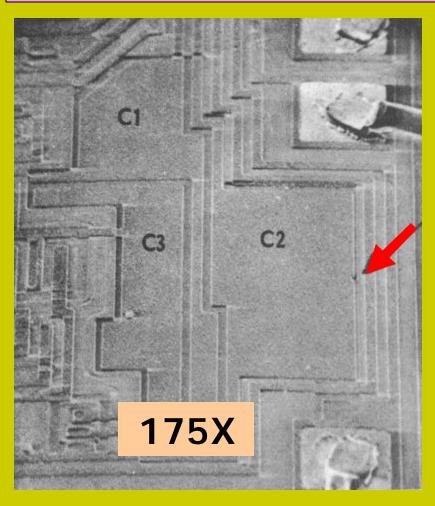
A failure that occurs during actual use because of an earlier exposure to an ESD event that did not result in an immediate detection of an out-of-spec condition.

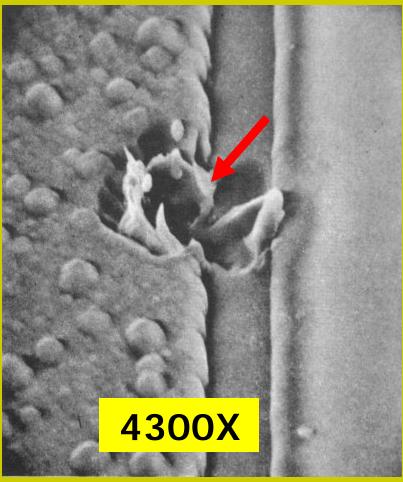
Results in:

- Reduced life expectancy.
- Decreased reliability.
- Intermittent failures.
- Reduced performance.
- High replacement cost when failure is detected.

ESD Damage

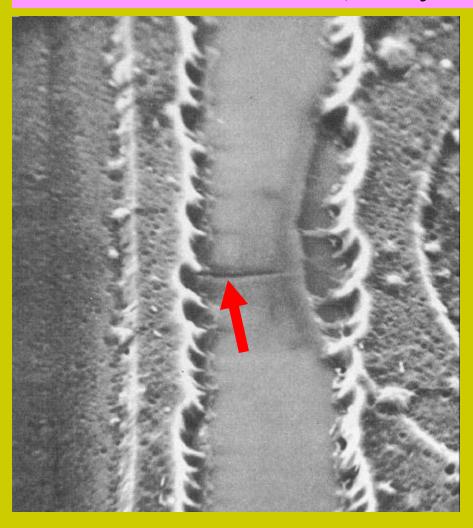
HA-2700 surface damage in the C2 MOS capacitor (Courtesy of JPL)





ESD Damage

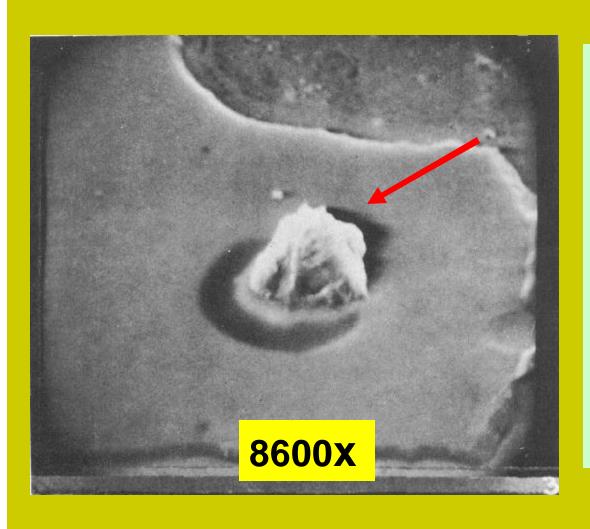
(Courtesy of JPL)



 Scanning electron microscope (SEM) view clearly showing the surface oxide crack produced by ESD.

ESD Damage

(Courtesy of JPL)



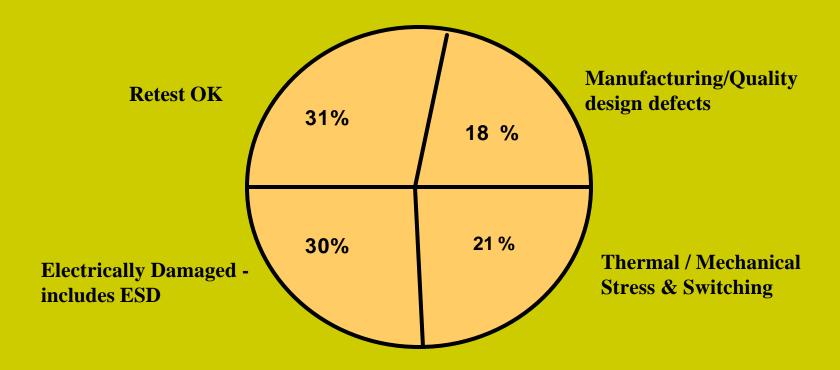
A close up view of the "punch-through" in the silicon dioxide (SiO₂)

Oxide punch-through induced damage is thermal in nature.

Failure Analysis Data: Jan. 1988 - Sept 1989

(Courtesy of 1999 ESD Symposium Proceedings)

Analysis of a product by a large U.S. company



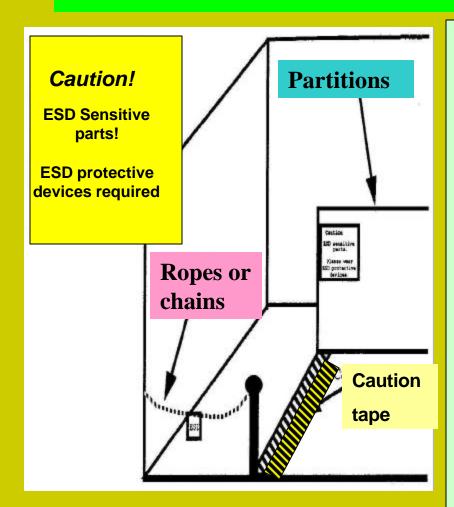
Most studies show that from 10 to 30% of all failures are ESD failures.



ESD Control Requirements

- **∠** Verify conformance of ESD protected areas/grounded workbench.
- Proper use of ESD protective equipment.
- **Avoid use of charge generating materials in ESD protected areas.**
- ESD audits and inspections.
- Inclusion of ESD requirements on documentation.
- **Control** the relative humidity.
- **∠** Use Faraday Cage containers to store and transport ESDS items.
- Air ionizer.

Verify Conformance of ESD Protected Areas



Page 9-1, para 9.2-1h, Quality Assurance

Quality Assurance shall be responsible for the internal auditing of the ESD-protected areas.

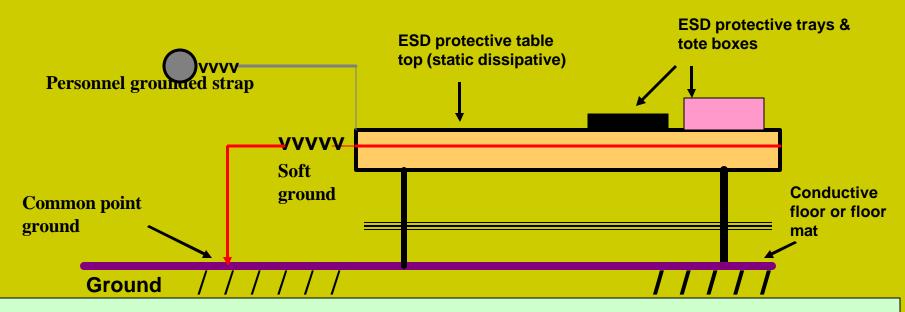
Page 7-1, Para 7.2-1 : ESD Area

The ESD-protected area, where ESDS items are to be processed, shall be clearly identified by prominently placed signs. Access to such areas shall be limited to trained and equipped personnel. A partition, rope guard, or similar means shall be set up to assist in prohibiting unauthorized and untrained personnel from entering the ESD-protected area. All other personnel shall be escorted and be equipped with standard protective clothing, as required.

Page 7-1,Para 7.2-2

The area shall be maintained in a clean and orderly condition. Smoking, eating and drinking in ESD-protected areas shall not be permitted. Materials unessential to the fabrication area are also prohibited at the work station.

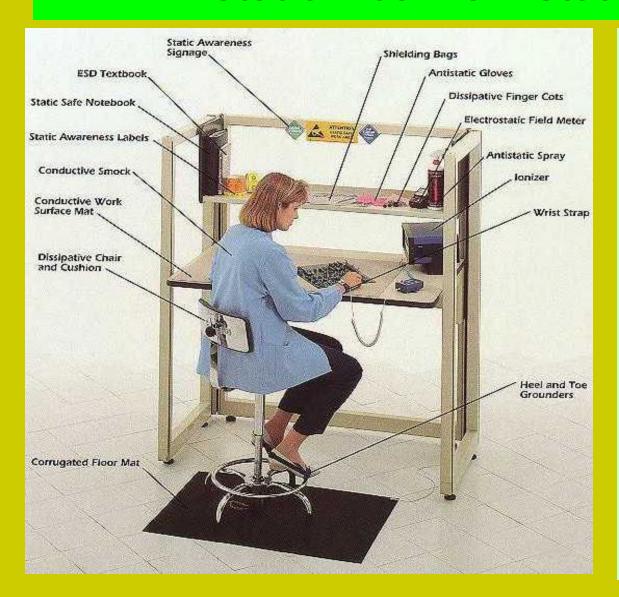
Typical ESD Grounded Work Bench



- <u>Page 7-1, Para 7.2-3a:</u> All work surfaces in an ESD-protected area shall be *static* dissipative and electrically connected to the *common* point ground.
- <u>Page 7-3: Note:</u> Work surfaces should be *soft* grounded to eliminate the safety hazard of touching a high voltage circuit with one hand and a hard ground with the other.
- <u>Page 7-4, Para 7.2-6:</u> The preferred practice is to use the third wire AC ground line for grounding all items at the ESD-protected work station.

CAUTION: Potential differences can exist in multi-point grounds.

Static Free Work Station



- Static Dissipative chair and bench mat
- Conductive smock
- Static awareness labels
- Static safe notebooks
- Static awareness signs
- Shielding bag
- ESD qualified gloves and finger cots
- Air ionizer
- Wrist strap
- Heel and toe grounders
- Etc.,etc.,etc.,

Wrist Strap

(First line of defense against ESD)



Current-limiting safety resistor provides protection for the wearer should a ground fault occur

Page 7-4, Para 7.2-5a

(1) Cuff:

The cuff shall ensure conductive contact with the wearer's skin. Metallic cuffs are preferred over fabric. Bead type chains are prohibited.

(2) Lead:

For operator safety, the wrist strap release force of the cuff and the lead shall occur with at least 2 pounds but not more than 5 pounds of force.

(3) Resistor:

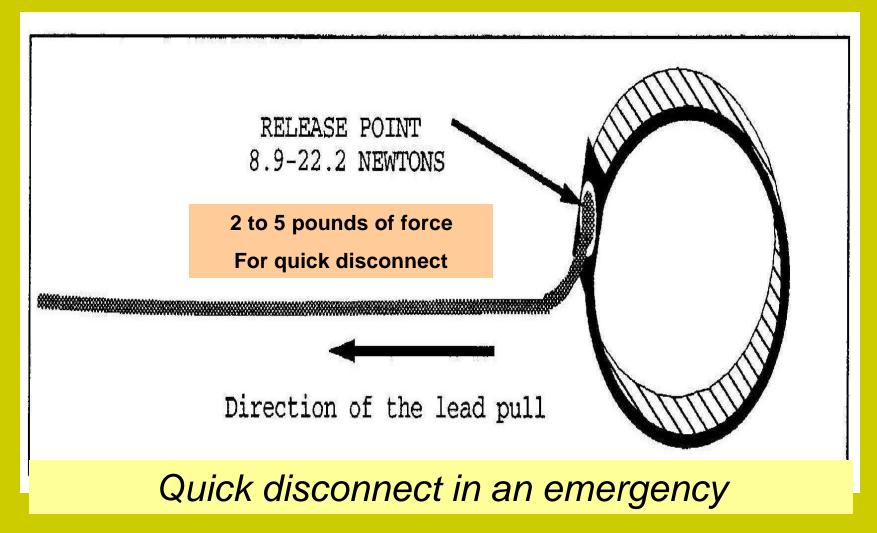
Shall contain an integral current-limiting safety resistor (1 Meg ohm \pm 20%). The preferred location is at the cuff end.

(4) Ground:

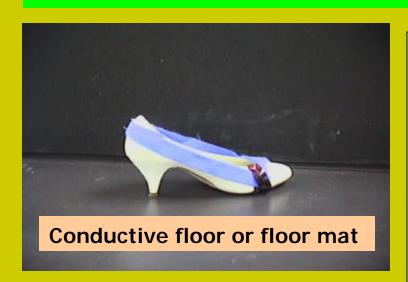
The wrist strap ground termination shall ensure a positive and durable connection between the lead and the soft ground.

Wrist Strap

(pull force requirement)



Heel and Toe Straps





<u>Page 7-4,Para 7.2-5b Foot Grounding</u> <u>Devices</u>

Leg, toe or heel straps or conductive shoes worn in conjunction with a conductive floor and/or conductive floor mats, are acceptable alternatives to a wrist strap in those situations where the operator needs to be mobile and the use of a wrist strap is impractical or unsafe. The integrity of foot-grounding devices shall be verified in the same manner as wrist straps.

NOTE:

- Foot grounding devices shall be kept clean so that contaminants do not inhibit their conductive interface with the floor.
- Worn on both feet to maintain continuity with the floor.

More ESD Protection



ESD qualified:

- Smocks
- Gloves
- Finger cots
- Solder extractor
- Dual-in-Line (DIP) insertion tool
- Shielded bag
- Tape
- etc., etc., etc.,

NO NO's in ESD Qualified Area



Page 7-1, Para 7.2-2

2. Materials unessential to the fabrication area are prohibited at the work station.

For example:

- Styrofoam/plastic cups
- Polyethylene, envelopes, sheets, bags, etc
- Scotch tapes, rubber bands, paper
- Plastic tote boxes
- Common bubble pack and packaging foam
- Tools not ESD approved

Air Ionizer

Ionizer generates positive and negative ions to neutralize electrostatically charged objects.

Like charges <u>repel</u> and unlike charges <u>attract</u>

Page 7-5, Para 7.2-8

Air ionizers are recommended where grounding is impractical.

Page 7-6: Caution:

The use of any type of air ionizer is prohibited in the presence of high-voltage or RF sensitive equipment to avoid breakdown in the presence of ionized air.

FYI: Since insulators do not conduct electrical charge, grounding will not discharge the static charge. Insulators will continue to hold the charge.

Handling of ESDS Items

Page 8-1, Para 8.2-1

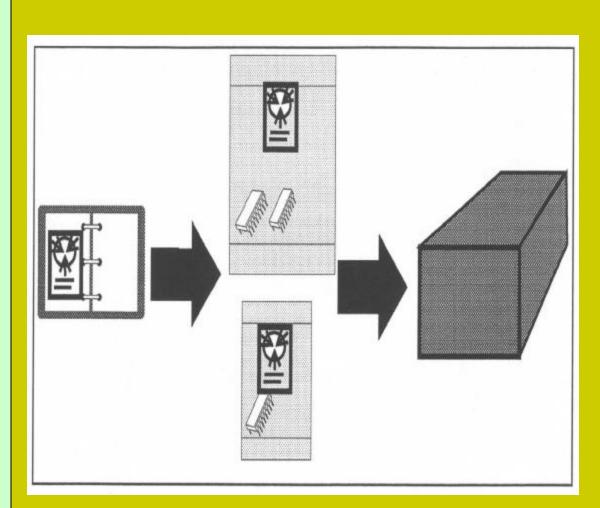
All ESDS items received shall be examined for proper ESDS precautionary marking and for ESD -protective packaging.

Page 8-1, Para 8.1-2

Accompanying documentation shall identify items as ESDS for appropriate handling.

Paperwork accompanying an ESDS item shall be contained in static dissipative bags or envelopes.

Paperwork shall not come in physical contact with an ESDS item.



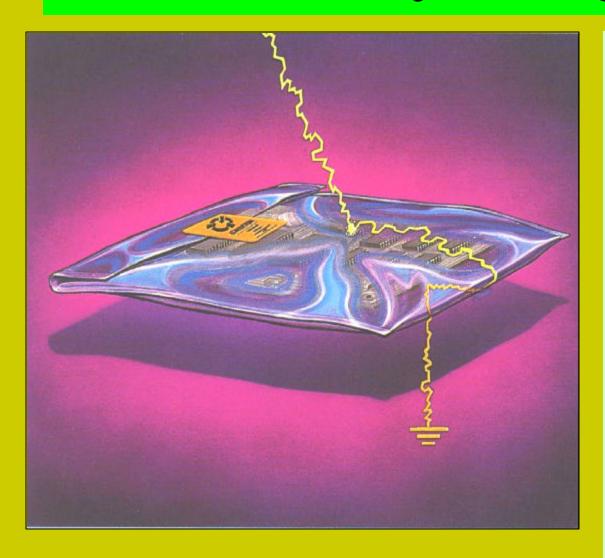
ESD Symbols



Page 8-2, Para 8.5

- Identification shall be placed so as to warn personnel before any ESD damaging procedure can be performed.
- 1a ESDS items shall be identified with either the sensitive electronic device symbol from MIL-STD-129 or the EIA specification RS-471 symbol.
- 3. Alternative identification shall be used as approved by the procuring NASA Center when the prescribed marking is not possible.

Faraday Shielding



- Faraday shielding protects ESDS items from direct discharge and electrostatic fields
- The conductive material redistributes the charge around the Faraday Cage container reducing the charge concentration.

Table 7-1, Page 7-2 ESD Control Program Verification Schedule and Required Measurements

Examples of required measurements

<u>Item</u>

Verification Intervals

Work surface Resistivity Monthly (Insulative/Static dissipative/Conductive)

Work Surface Grounding
(common point)

Humidification (30 to 70% relative humidity) Continuous

Cardinal ESD Rules

- Assume all electronic devices & equipment are susceptible to ESD damage or failure (You can't tell just by looking at it)
- Always wear a wrist strap when handling ESD sensitive devices & assemblies
- Always package, store, & handle electronic devices & assemblies in a safe, static preventive manner.

In Summary

- Static electricity is due primarily to material contact or triboelectric charging.
- **ESDischarge** is the destructive component for electronic parts.
- Reduce or eliminate the electrostatic charge and the voltage potential is reduced.
- To protect ESDS parts and/or assemblies:
 - 1. Use ESD qualified tools, equipment, wrist strap, clothing, etc.
 - 2. Use ESD qualified work bench/ area to open and work on ESDS items.
 - 3. Allow only ESD trained personnel to work on ESDS items.
 - 4. Control the relative humidity of the work area.
 - 5. Use Faraday Cage container to store and transport ESDS items.
 - 6. Use air ionizer to neutralize static charge.

REMEMBER: Only YOU can prevent that SPARK / DAMAGE to electronic parts and assemblies.



END OF SLIDE PRESENTATION